Astrophysicists recreate stars in the lab

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Astronomers are recruiting the physics laboratory to unravel the high energy processes involved in formation of stars and other critical processes within the universe. Experiments with high energy radiation and plasmas in the laboratory involving temperatures and magnetic fields over a million times greater than normally encountered on earth are also producing spin off benefits for important applications, notably in the drive towards nuclear fusion as a source of clean carbon-neutral energy.

Although a great deal has been learnt through a combination of theoretical models and observation of the universe right across the electromagnetic spectrum including visible light with conventional optical telescopes, many questions on energetic processes taking place billions of miles away still remain unanswered.This is why astrophysicists are turning to a third ingredient, the high energy laboratory, fusing results obtained there with theoretical models and direct observation through instruments. The state of this highly promising field was discussed at a recent workshop organised by the European Science Foundation (ESF), which also set out a roadmap for future collaborative research in Europe over the next five years.

The workshop is setting up a European framework for conducting coordinated experiments in Extreme Laboratory Astrophysics (ELA), aiming to simulate the high temperatures and magnetic fields experienced in a variety of formative processes occurring throughout the universe's history. Full blown ELA builds on earlier more tentative initiatives, such as the JETSET network, which is a four-year Marie Curie Research Training Network (RTN) funded by the European

Commission, designed to build a vibrant interdisciplinary European Research and Training community centred on rigorous and novel approaches to plasma jet studies, with a focus on flows produced during star formation. Plasma jets comprise high energy atomic nuclei stripped of their electrons, expelled from stars during their formation and early in their lives.

ELA experiments however, as discussed at the ESF workshop, go much further than the study of plasma jets, and therefore expand on the foundations created by JETSET. "The JETSET network was truly innovative in that it combined not only theoretical and observational astrophysics, but also for the first time experiments," said Andrea Ciardi, convenor of the ESF workshop and plasma physicist at the Ecole Normale Superieure in Paris. "However JETSET was limited in terms of astrophysical phenomena studied (jets from young stars) and in terms of groups involved. The workshop aims at the creation of an XLA framework combining numerical modelling, experiments and theory, to complement observations in the study of a broader range of astrophysical phenomena."

The workshop fulfilled its objectives of stimulating the required interdisciplinary research effort, and providing a broad outlook of future objectives. Furthermore it generated great excitement about prospects for the field, according to Ciardi. "The workshop covered a large spectrum of research both in astrophysics and in laboratory plasma physics: from cosmic rays acceleration, to the properties of fast winds in stars, and from high-power lasers aimed at achieving fusion to experiments producing magnetic bubbles expanding at hundreds of kilometres per second," said Ciardi. "Indeed the excitement comes from being able to re-create in the laboratory astrophysical phenomena taking place in some of the most extreme and exotic objects in the universe."

The ELA experiments should also have practical benefits. "ELA research has an inherent duality: experiments developed initially for laboratory astrophysics, including new diagnostics, theoretical and numerical models, can be useful for example to fusion research, which is pursuing a clean source of energy, which in some cases uses similar theoretical and experimental techniques," said Ciardi.

ELA research could also help improve weather forecasts by leading to better understanding of cosmic rays that strike the earth's atmosphere and have a significant effect on cloud formation and thunderstorm activity.

Source: European Science Foundation